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By E.J. Holmyard

The notable interest in the work of medieval Muhammadan chemists which has arisen in the last few years probably has its origin in a fuller appreciation of the fact that the numerous puzzling problems presented by European chemistry of the early middle ages cannot}be solved until a thorough investigation has been made of the rise and development of chemistry in Islam, whence it was imported to Christendom during a long period beginning in the first half of the twelfth century. Two of the earliest historians of chemistry to realize the importance of this study were Berthelot and Prof. Eilhard Wiedemann. Whilst the scholarly researches of the latter have been comparatively neglected in this country until recently, probably because they were generally published in somewhat obscure local German periodicals, Berthelot’s monumental work in three volumes (La Chimie au Moyen Age, Paris, 1893) at once attracted attention, and has been used, for the most part quite uncritically, by all later writers. It seems, therefore, of fundamental importance that we should arrive at a clear knowledge of the length to which Berthelot may be safely followed, of the accuracy of his conclusions and of the relation which the ground he covered bears to the whole field.

There can be no doubt, to my mind, that Berthelot’s work is deserving of the most generous praise. All those who since his time have studied Islamic chemistry owe him a great debt, acknowledged or unacknowledged, and von Lippmann’s section on the subject, in his invaluable *Entstehung und Ausbreitung der Alchemie*, is based principally upon *La Chimie au Moyen Age*. That remarkable genius, Moritz Steinschneider, expresses his opinion of Berthelot’s researches in the following words:

> “Mit dem grossartigen Werke von Berthelot, La Chimie au Moyen Age (1893), dessen 3 Band die arabische Chemie, bez. Alchemie, behandelt und einige der Altesten arabischen Schriften mit franzdésischer Uebersetzung von O. Houdas enthilt, mégen Physiker, die sich fiir Geschichte ihrer Wissenschaft interessieren, den Gegenstand fiir erschépft halten; ja auch

> diejenigen, welche die Kulturgeschichte der Araber und deren Bedeutung fiir die Geschichte des Mittelalters nicht unterschitzen, diirften die Resultate Berthelots als fiir ihren Zweck ausreichend ansehen und ohne weitere Forschungen verwerten.” [1]

Coming from such an eminent authority, this praise is high indeed, and although —however diffidently, we may protest against an Arabist expressing such a dogmatic opinion on what is primarily a matter for chemists to decide, it comes as somewhat of a shock to find that Prof. von Lippmann? passes extraordinarily severe strictures upon “Berthelot als Historiker.” [2] von Lippmann, of course, wrote his book during the late war, when feeling ran high, and would possibly have employed less scathing terms under normal circumstances; but the fact remains that Berthelot’s reliability has been seriously impugned, and until the matter is satisfactorily cleared up no historian of chemistry can feel safe in accepting, or rejecting, Berthelot’s conclusions.

It is in the hope of throwing a little light upon this obscure situation that the present articles have been written. It will be convenient to arrange the discussion under three heads (1) Berthelot’s qualifications for his task; (2) his choice of material; (3) his treatment of the material chosen, and his conclusions.

Berthelot’s qualifications for his task

It will, I think, be generally agreed that the historian of chemistry must primarily be a chemist, for otherwise he is fatally handicapped from the start. No one can dispute Berthelot’s possession of this essential qualification.

Secondly, it does not appear unreasonable to insist that a man who sets out to make original investigation of a hitherto unexplored region in the history of a science should have an adequate knowledge of the language and literature of the men whose works he proposes to study. Berthelot, however, as is well known, had not even a bowing acquaintance with Arabic, and was therefore forced to rely upon translations. These translations were made for him by Prof. 0. Houdas, an excellent Arabia scholar famed especially for his translation of Bukhari’s “*Traditions of the Prophet*.” It would seem, at first sight, as though this solution of the difficulty was comparatively satisfactory, but further consideration, will show us (a) that, even for the actual work of translation, some knowledge of chemistry is essential, and this Houdas did not possess, and (b) that to translate a technical work from any language presupposes in the translator an adequate understanding of the technical terms and phrases employed, and an acquaintance with cognate works in the same and other languages. This second point is of especial importance in a subject so obscure as alchemy and in a language of so rich a vocabulary as Arabic. I believe I am correct in saying that Prof. Houdas had no special knowledge of Arabic chemical treatises, and that he undertook the work of translation only at the special request of Berthelot, backed by the Ministére de l'Instruction Publique. My opinion, which I have less hesitation in setting down here in that it is supported by two eminent Arabists, namely, Prof. E.G.Browne and Monsieur E.Blochet, is that properly to understand an Arabic work on chemistry requires both intensive and extensive concentration, and that even the best Arabic scholar would not produce a satisfactory translation of such a work unless he was familiar with many others of the same genre. I may, perhaps, quote Prof. Browne's own words, taken from his admirable book on Arabian Medicine:

> "I have been greatly hampered in my reading of Arabic medical books by the difficulty of determining the exact scientific signification of many words used in the ordinary literary language in a looser and less precise sense than that which they evidently bear in the technical works in question. Nor is much help to be derived from the medieval translations of the " LatinoBarbari,"" who too often simply preserve in a distorted form the Arabic term which they pretend to translate." [3]

If one of the greatest living Arabists, himself a qualified physician, feels this difficulty in dealing with medical works, at what sort of disadvantage must an Arabist of purely literary training find himself when confronted with texts dealing with alchemy, a subject. far more involved than medicine 2? Prof. Blochet remarks [4],

> "le sujet est extrémement obscur et la traduction de M. Houdas souvent insuffisante:"

In spite of the difficulties with which he had thus to contend, Prof. Houdas in point of fact made translations which under the circumstances must be regarded as extremely good, and they certainly are worthy of his scholarship. At the same time they often fail, as might be expected, in those very places in which accuracy is essential, namely, the technical words and phrases. To take a case in point: one of Jabir ibn Hayyan's books is entitled Kitab Abi Qalamiin. Houdas translates [5] this as “un livre & Qalamoc,” by reading ild instead of abi, which is in itself an immaterial mistake; but he obviously was not aware of the fact that Abu Qalamiin was commonly employed by chemists as a name for the jasper, the correct translation of the title thus being “The Book on the Jasper.”

Similar mistakes are numerous; thus he treats the word ustugus as a proper noun [6] and leaves it untranslated, whereas anyone acquainted with Jabir’s writings knows that wstuqus signifies “‘ the four elements” of Aristotelian philosophy; and in the same place he misreads ds (myrtle) for “uss (base or foundation), thus rendering his translation not merely unintelligible but ridiculous.

Houdas’ translation thus inevitably suffers from his lack of technical knowledge, so that, even if this were all, we should be compelled to admit that Berthelot was beginning his work upon a doubtful basis. But when we read [7]

Berthelot’s statement,

“*j’ai revisé avee soin cette traduction littérale* [8], de façon a tâcher de lui donner un sens intelligible, autant que le comporte ce genre de littérature,”

and remember that he knew no word of Arabic, we cannot deny that he is willfully breaking one of the first canons of literary criticism and laying himself open to grave censure. It is, indeed, difficult to see what justification a man could possibly have for believing himself capable of revising a professedly literal translation from a language of which he was admittedly completely ignorant. Especially is this true in the case of a work which was the first of its kind to be translated into a modern European language, and of which the very atmosphere was strange.
There is, however, no need for us to make the uncharitable assumption of Prof. von Lippman, [9] and ascribe this lapse from sound scholarship to Berthelot’s egoism and conceit.

It is much more likely that he was inspired by an earnest desire to throw as much light as possible upon the subject, and succumbed to the fatal temptation of trying to make sense instead of adopting the more toilsome but only sure path of finding out the sense by a comparative study of the whole field, or of at least a much wider portion of it. We have seen, therefore, that Berthelot’s whole work on Arabic chemistry rests upon an insecure foundation, since, to use the words of Prof. Ruska, the translations of the Arabic texts upon which he relied suffer from

> “zahllosen Ungenauigkeiten und durch vorgefasste Meinungen bedingten, irrtümlichen Auslegungen.”

There are, however, some factors which tell In the opposite direction, and these must now be considered. It has long been known (a) that chemistry was introduced into Islam chiefly from the Greek school at Alexandria, and (b) that medieval European chemistry was a direct legacy of Islam. If, therefore, a man were thoroughly cognizant of both the source and the fruit of Muhammadan chemistry he would have a very valuable qualification for dealing with the latter itself. So far as I am aware, no one has disputed Berthelot’s comprehensive knowledge of European chemistry of the middle ages, and we need have no hesitation in saying that the disadvantage under which he lay from having to rely on translations was thus partially neutralized. Partially only, however; for on the one hand he could not be in a position to throw any light on those problems which had their origin in Islam and were often transported bodily and unintelligibly into the Latin world, and on the other lay the pitfall of reading into the Arabic works meanings and conceptions which were, in fact, of spontaneous and later European birth. Berthelot has, indeed, not been successful in avoiding either of these dangers; on the contrary, he has often failed, in addition, to realize that numerous facts and theories which he believed to be definitely European are to be found in the writings of Muhammadan chemistry. In not a few cases the errors which he thus almost inevitably made are of capital importance.

In the other direction we have to gauge the extent of his knowledge of Greek alchemy. In 1888 he published his *Collection des Anciens Alchimistes Grecs*, in which for the first time texts of the writings of these authors were made available. Of the worth of this collection I am not in a position to judge, but it is to be noted that, as in the case of the Arabic works, the translation was not made by Berthelot himself, but by Prof. Ruelle, and that the latter’s version was subjected to the same treatment by Berthelot as was undergone by that of Prof. Houdas. One therefore has the uneasy feeling that, here also, one may be on uncertain ground, and although Prof. Gaster has expressed a high opinion of the work, other scholars have not been slow to pass very unfavorable judgments upon it. I think we may, however, be fairly safe in assuming that Berthelot had a pretty good general idea of Greek alchemy, and may therefore admit that he was in a position to recognize Greek ideas and influence in Islamic chemistry, though perhaps in matters of detail he was liable to go astray.

To summarize the points made in this section before proceeding to a discussion of Berthelot's choice of material, it may be said:

(a) Berthelot possessed the first essential of a historian of chemistry in that he was a chemist.

(b) He had, however, no knowledge of Arabic and was compelled to fall back upon translations.

(c) These translations are untrustworthy and inaccurate from a technical point of view, which, in this case, is the vital one.

(d) They are further vitiated by the fact that Berthelot subjected them to a "revision" which, from the very nature of things, was bound to be uncritical, in order "to make sense."

(e) He had an adequate Imnowledge of medizval European chemistry, which would help him to understand much of the Arabic work but which would leave him helpless in those very points where help was most needed.

(f) He often ascribed to Europe knowledge which came from Islam.

(g) He had a better knowledge of Greek alchemy than anyone else, and was therefore able to appreciate Greek influence on Muhammadan chemical thought. But his ideas and scholarship as expressed in the Collection des Anciens Alchimistes Grecs have since been severely criticized by those qualified to judge.

(h) Finally, one may add that Berthelot possessed an inveterate habit of sweeping away as "incomprehensible" anything which he could not himself understand.

Perhaps I may be allowed to give my own experience, for what it is worth. Starting with an implicit faith in Berthelot, naive perhaps, but natural at the sight of his imposing volumes, which give one the impression of finality, I have been gradually led to a profound and progressive distrust, until at the present moment I feel that it is quite unsafe to accept any of his conclusions without first referring to the original sources or without strong collateral evidence. This, of course, does not imply that all are wrong; many are accurate, many others require only slight modification, and *La Chimie au Moyen Age* contains a vast amount of material of the greatest value; but the whole is marred by the circumstance that every fact has to be checked, every statement verified, every identification investigated and every translated phrase compared with its original. It is only natural that historians of chemistry, who have for the most part accepted Berthelot's work as authoritative, should have drawn thence both the true and the false, and that thus there have crept into the literature errors which will probably prove extremely difficult to eradicate. Even the late Prof. Campbell Brown, whose excellent History of Chemistry has acquired a well-deserved reputation for insight and accuracy, relied entirely upon Berthelot for his account of oriental chemistry, with the result that his pages are disfigured by gross inaccuracies, ludicrous transliterations and seriously incorrect conclusions.

Berthelot choice or material

About 300—400 different Arabic treatises on chemistry are known, and it is probable that a great many more exist in private libraries in Muhammadan countries. The Bibliothéque Nationale contains some 30 distinct MSS., and there are several of importance in the library at Leyden. The richest European libraries in this connection are, however, the British Museum and the National Library at Berlin. The Royal Library at Cairo contains a large number of alchemical MSS., and I have been told that the King of the Hijaz possesses a fine collection, although I cannot vouch for the accuracy of this statement.

The works vary considerably in both age and importance. The majority range from the eighth century to the fourteenth, though

is good reason to suppose that, in the main, the writings have been accurately transmitted. This does not imply, of course, that instances of pseudo epigraphy are rare; what is meant is that, once a work was written, it was usually carefully copied, so that, although,for example, the earliest extant MS. of an eighth century book may be of the thirteenth century, we may with some confidence assume that it has not undergone serious change in the process of transmission. 10

The problem which Berthelot wished to solve was two-fold: in the first place he desired to find the relation which existed between the alchemy of the Greeks and that of the early Muslims, and secondly he was anxious to discover whether certain of the Latin works of the early Middle Ages were really, as they professed to be, translations from the Arabic. He also incidentally wished to find whether the Arabic works of Jabir ibn Hayyan showed any resemblance to those of the Latin Geber. It is clear, therefore, that he intended to limit himself to a study of the earliest and latest periods in history of chemistry in Islam, and this is in fact exactly what he did, neglecting entirely the intervening period of three or four centuries. This limitation must be borne in mind when we come to criticize his choice of material, and it is necessary to point out that those historians of chemistry who have assumed that Berthelot investigated the whole period and gave merely the most important and interesting works in his book, have made a grave error for which the only excuse is that Berthelot himself is lable to give one that impression.

Berthelot’s immediate objective, then, was (a) to have recourse “aux ouvrages arabes euxmémes et de les comparer avec les textes latins, réputés traduits d’aprés des cuvres congénéres [11]; and (6) to have translated from the Arabic those treatises or compilations “ot il est particuliérement question des alchimistes grecs, et, de l’autre parte, les ouvrages qui portent le nom de Jabir ibn Hayyan.”

With regard to (a), we find that Berthelot did not succeed in discovering, or at least did not use, any work that is known in both Arabic original and Latin translation. It is true that up to the present very few of such works have been found, but one at least he had at his disposal in the Liber Secretorum Bubacaris (Paris MS. 6514, pp. 101-112), of which the Arabic text occurs in the two MSS., one at Leipzig and a second at Géttingen. He gives a summary of the Latin version at pp. 306-310 of volume 1 of *La Chimie au Moyen Age*, and recognises that it is undoubtedly an Arabic work. It is, therefore, strange to find that he omits to give the Arabic text, as he had here ready to hand an excellent piece of material for aiding him to arrive at a definite conclusion on one of the questions under consideration. If the reason for this omission is that he was unaware of the existence of the Arabic MSS., he cannot be acquitted of the charge of negligence, for the Leipzig MS.is very fully described in the catalogue of the City Library published in 1838. If, on the other hand, he knew of the Arabic version (which seems improbable), but considered it unimportant, he showed a serious lack of judgment, for this work of * Bubachar ”’ (¢.e., Abu Bakr Muhammad ibn Zakariyya al-Razi, or Rhazes) is, as Prof. Ruska has pointed out, of the greatest value as a compendium of the practical chemical knowledge of Islam in the tenth century. Of other Latin works which Berthelot considered to be, in all probability, translations from the Arabic, he was unable to find originals, and therefore was not in a position to arrive at trustworthy conclusions concerning them. We may therefore, I think, fairly say that as far as regards point (a), Berthelot left the matter in practically the same state as that in which he found it, and that the whole problem is still to be solved. It is for this reason that the appearance of Prof. Ruska’s promised edition of the Leipzig and Gottingen MSS. of the above work is eagerly awaited.

To turn now to point (b). Berthelot gives the texts of the following works which bear unmistakable signs of Greek influence:

> “un livre attribué a Ostanes; un extrait du ms. 1074 (Bibl. Nat.) renfermant

> une série de citations des alchimistes grees; le livre de Cratés; et le livre de El-Habib.”

Of these, the last two are taken from the Leyden MS. 440, which Prof. Houdas was inclined to think “nia pu étre écrit postérieurement au VII* siécle de Vhégire et date méme plut6t du VI° siécle,” whilst the first is in the Bibl. Nat. MS. Arabe 2605, written partly in the year 1337 a.p. (738 of the Muhammadan era).
Of these it is sufficient here to say that the choice, though small, is quite sufficient for the purpose and on the whole satisfactory; the inclusion of the works by “Ostanes” is perhaps unfortunate, as the Ostanes question is almost as puzzling as that of Hermes himself, and at once introduces many side issues of a mystical and theosophical nature, thus further complicating a problem which is already quite difficult enough. Still, the works which Berthelot chose enabled him to prove conclusively what had before been a matter of conjecture (although there was not in reality much doubt about it), namely, that Arabic. chemistry is very largely derived from neohellenic sources as is, indeed, definitely stated by the Muslims themselves. Berthelot’s work here, however, is of value not merely in that it proved this transmission but because it showed also the nature and extent of the ideas that were transmitted, the names that were honored and some of the theories that were generally accepted. If the treatises of Ostanes and the others are to be taken as typical of the Greek alchemy which was the seed of chemistry in Islam, we can gain a good idea of the progress that was made by the Muslims, for as Berthelot remarks, “il y a peu de chose sans doute a tirer de, the books ascribed to Ostanes, pour la chimie positive.’” [12]

The only criticism which need be made of Berthelot’s choice in this connexion is that as Khalid ibn Yazid is unanimously described as the first Muslim who had translations of Greek alchemical works made, and studied the subject himself with ardour, it would seem that an investigation of his writings might have afforded more definite information than do the works of the anonymous or mythical authors such as Crates and Ostanes. Much of Khalid’s chemical verse is easily available, and I believe that his complete (?) Diwdn is preserved at Constantinople.

It is, perhaps, in his treatment of Jabir ibn Hayyan that Berthelot most signally failed. A proper appreciation of the work of a man who wrote some 500 books cannot be gained by a study of only nine, and these not the most important. I do not propose in this place to offer any comment on the vexed question of the possible identity of Jabir with Geber, but will confine myself to pointing out that some 80 works of Jabir are still extant, whole or fragmentary, and that a study of them enables one to see clearly the reasons which led later chemists to regard their author with an extraordinary reverence. The choice of Jabir's works made by Berthelot is entirely misleading and inadequate. The extent of his knowledge was amazing, and to regard him as a bombastic obscurantist, as Berthelot does, is to do him a grave injustice. I hope to show later the remarkable scientific knowledge he possessed but meanwhile I may perhaps refer to a bibliography I have made of his extant works, now in the press, [13] where those who are interested may gain some idea of the negligible relation which exists between the works published by Berthelot and those which were available for his study if he had cared to make a search.

To sum up:

1. Berthelot made no attempt to study the whole field of Arabic chemistry, an important fact which has, as a rule, not been observed by historians.

2. He neglected entirely the development of chemistry in Islam in its most flourishing period.

3. He confined his attention to three points, (a) Arabic originals of Latin works, (b) Greek influence, and (c) the works of Jabir and their relation to the Latin works of Geber.

4. As regards (a), he made scarcely any addition to our knowledge. As regards (b), his choice of material was sufficient and he proved his point, although he did not exhaust the subject and his material might have been better chosen. As regards (c), he proved that the Latin works could not have been translated the Arabic works he published, but he did not (alfa) prove that the Latin works were not based on Arabic originals, nor (beta) did he give an adequate account of Jabir's knowledge, choosing only nine works: out of some 80 available.

In the second article I shall deal with Berthelot's treatment of his: material and with his conclusions, but meanwhile it has been made clear (1) that, as far as Arabic chemistry is concerned, he is not a safe guide, (2) that he touched only the fringes of the subject, (3) that his choice of material was extremely inadequate, and (4) that in the case of the one chemist of whom he made a professedly detailed study he gave a very inaccurate picture based upon a negligible fraction of the data which are available. This is a serious indictment, but I believe it to be made with justice and to be based, as I have tried to show, upon irrefutable evidence.

Part II

In the first article Berthelot's qualifications for the study of Arabic chemistry, and his choice of material, have been considered. It now remains for us to examine (1) his treatment of the material chosen and (2) the conclusions at which he arrived.

Berthelot's treatment of his material

The manuscript material which Berthelot employed comprises 13 different works, of which nine are attributed to Jabir ibn Hayyan. The whole 13 occupy 205 pages of Arabic type and 180 in the French translation. In addition to the manuscripts, he had at his disposal (a) the catalogs of the chief European libraries, many of which contain valuable critical and bibliographical notes, (b) the *Kitab al-Fihrist* in Fluegel's edition, (c) the Biographical Dictionary of Ibn Khallikan in English translation, (d) the *Prolegomena* of Ibn Khaldiin in French translation, (e) the *History of the Philosophers*, by Al-Qifti, (f) the *Classes of Physicians* by Ibn Abi Usaybiʻa, and (g) the celebrated bibliography, the *Kashfu'l-Zunun*, of Hajji Khalifa; to name only those important sources to which one would naturally turn. Of the last six he claims to have used all except e and f, but it is clear from his book that whilst he has quoted the whole of the appropriate section of the *Fihrist* and much of the passage in Ibn Khaldun, he has not drawn very much from Hajji Khalifa, although a Latin translation of the *Kashfwl-Zunun* was published by Fluegel many years previously (1838-1858). Of the catalogues of libraries he makes scarcely any mention and seems indeed to have neglected this valuable source of information. The section of the *Kitab al-Fihrist* (987 A.D.) dealing with alchemy was translated by Houdas and is given at pp. 26-40 of volume I. of *La Chimie au Moyen Age*. The Fihrist is of great value for the history of alchemy, as it gives a list of the early alchemists and the titles of many of their works, but Houdas' version is unprovided with notes or critical apparatus of any kind and contains several inaccuracies in translation and some very doubtful identifications. Thus *Afragasus* is identified [14] with an uncertain Africanus,

in spite of the fact that the latter name is in Arabic *al-Ifrigiyyu*, whilst the suggested identification [15] of Arkaghanis, as well, with Africanus has nothing whatever to recommend it.

In short, the data provided by the Fihrist have simply been thrust into the book without any attempt at digestion, and anyone who is carrying out research on the subject will get no assistance from Houdas rendering. This, however, is perhaps beside the point, which is whether Berthelot himself found it useful. In so far as the passage had never been translated before, it was no doubt interesting and gave a bird’s eye view of the range of Arabic alchemy of the first three centuries of the Hijra, but its true value, which, as has been remarked above, is considerable, cannot be appreciated, nor can the passage itself be properly used, without a knowledge of a great many of the early alchemical works themselves. It is clear that Berthelot realized this, for he leaves the section entirely without comment. The other authorities are treated in the same cursory fashion, no attempt being made to arrive at a general idea of the course of Arabic alchemy, even up to the time of the Crusades, which was the limit which Berthelot set himself. Twelve pages of heterogeneous facts are, indeed, all that he appears to have extracted from the rich bibliographical sources he had immediately available. Even these facts are often incorrectly given. Thus there is no excuse for assigning Ibn Sina (Avicenna) to the twelfth century, [16] when the dates of his birth and death are well known to have been 980 and 1037 respectively;

the date of the death of Al-Tughra’i, definitely given as 1122, [17] is in reality uncertain;

Ibn Amyal (or better Umail) al-Temimi lived not in the twelfth century a.p [18] but about 900 a.d.;

Abn Casba ibn Temmam al-Iraqi [19] should be Abu’l-Asba; Djeldeik (rather Jildaki), placed between Ibn Hasan Ali (i.c., Burhan al-Din Abu’l-Hasan Ali ibn Musa ibn Arfa’ Ra’s), who died probably in 1197, and Al-Ghazzali (died 1111), lived in the fourteenth century and died at Cairo somewhere about 1360.

The famous controversy as to the reality of alchemy arose not in the twelfth century, [20] but in the first half of the ninth, in which period Ya‘qub-al-Kindi lived.

Khalid ibn Yazid died in 704, not 708, [21] whilst the date of the death of Maslama al-Majriti [22] is not definitely known, and there is good reason to suppose that he never wrote on alchemy at all.

Instead of its being the fact that “la plupart de ces traités (of Arabic alchemy) ont disparu,” [23] at least two-thirds of those mentioned by Hajji Khalifa in his article on *Alkimia* are still extant, although of course a great number of the very early ones have been lost. Of the list of 22 works quoted by Berthelot on pp. 41 and 42, about 10 are known in MS.

In dealing with the Latin works on alchemy ascribed to Avicenna, he has made a great many identifications which are, to say the least, very improbable; thus King Galud of Babylon is definitely identified with Khalid [24] without any reason given;

Zucrat, obviously Suqrat, or Socrates, is surprisingly called Zoroaster; Clard is given as “Caton”; Zabaibar appears to be identified with Vergil, for reason not given; [25] whilst Alpharabi, who is clearly Abu Nasr al-Farabi, is not identified.

The “Jahie Abendinon” of Avicenna’s list is unknown, but it has occurred to me that he may have been a son (Yahya) of the Egyptian alchemist and Sufi Dhu’n-Nun, and that “Jahie Abendinon” may be a crude translation of Yahya ibn Dhi’n-Nun. I do not know, however, whether Dhu’n Nun ever had a son, and I can find no trace of such a person as an alchemist. Dhu’n-Nun himself died in 860 a.D., so that his son would have lived in the ninth century, a date not incompatible with his inclusion in a list of Avicenna’s.
It will be seen that Berthelot’s introductory matter is meagre, that it has not been properly dealt with, and that it contains numerous inaccuracies which might easily have been avoided, and many doubtful identifications. It is, therefore, of very little help to a study of the manuscript texts themselves, and is often misleading. In other words, the published texts stand practically by themselves and have to be considered on their own merits, except for the light which Greek alchemy throws upon them. The manuscripts employed, especially the Leyden MS. 440, were not in a very good state, that volume, indeed, having been

> “ mouillé dans sa partie inférieure,” so that “les trois ou quatre derniéres lignes sont souvent a moiti¢é effacées, et parfois certains mots ont été complétement rongés par lhumidite.”

This rendered decipherment in many places uncertain, and in many others impossible. The major portions of the texts were, however, in good condition and the readings "presque toujours" certain.

The MSS. were transcribed by Houdas and printed in Volume III of *La Chimie au Moyen Age*, accompanied by a French translation as revised by Berthelot according to the peculiar canon mentioned in the previous article, namely, with the object of "making sense."

Pages 9-23 give short descriptions of the treatises, together with a few notes. The annotations which accompany the translations deal almost entirely with resemblances of certain passages to passages of Greek alchemists, and the references are usually to the *Collection des Anciens Alchimistes Grecs*. In other words, Berthelot did not attempt the task of a proper elucidation of the translations, but confined himself to one definite point. This, as has already been said, he sufficiently proved; nevertheless, on the main question of the nature and development of Arabic chemistry he is perforce silent, and the historian will not derive much help in this direction from a perusal of the book. The works of Crates, Al-Habib and Ostanes, given by Berthelot, are indeed remarkable, not as being typical of Arabic chemistry, but because they are exceptional. I know of only one other MS. of "Ostanes" treatise, and I have never come across a reference to those of Crates or A-Habib in Jabir, Al-Razi, Burhan ad-Din ibn Arfa'Ra's, Abu'l-Qasim al-Iraqi, Ibn Sima, the pseudo Maslama al-Majriti, Aidamir al-Jildaki, or in fact, in any other Arabic chemical writer, so that I do not believe that they can have had any considerable influence. Many of the ideas and much of the phraseology in them are of course common, but the works themselves appear to have been almost completely neglected by Muhammadan chemists. On the other hand, most of the books of Jabir which are given by Berthelot are frequently quoted by later authors, and there is no reason to doubt their authenticity; they do not, however, give an adequate picture of their author. In using the texts one finds at once the difficulty of referring to any particular passage, as the pages of the MSS. are not numbered, neither are any indications given in the Arabic of the corresponding pages in the translation. This would not be a drawback in the case of a work divided into numbered sections and subsections, but it is very aggravating in the long and rambling treatises chosen and causes a great waste of time. Moreover, the texts themselves cannot be said to be properly established, since they were made from single manuscripts, often imperfect. With the books of Crates and Al-Habib this was inevitable, since no other MSS. are known, but another MS. of the Ostanes is in the British Musuem, and MSS. of the "Book of Royalty" and "Little Book of Mercy" are fairly common. The "Books of Mereury" and the other books of Jabir are freely quoted by Al-Jildaki and others, and their texts could thus have been partially checked. In the first volume of *La Chimie au Moyen Age*, Berthelot brings to bear his knowledge of medieval Latin treatises supposed to have been translated from, or based on, Arabic originals, but, as has already been pointed out, he is here attempting to explain *ignotum per ignotius*. In the Latin works it is impossible to separate the indigenous from the foreign, whether in ideas or in facts, without a previous knowledge of the later developments of Arabic chemistry, especially in Spain; now it is of Spanish-Arabic alchemy that we know least. A work of capital importance here is the *Rutbatu'l-Hakim*, ascribed, probably falsely, to Maslama al-Majriti, who died in the early years of the eleventh century, and it is to be hoped that the task of editing, translating and annotating this valuable book will be undertaken at no distant date. The *Liber de Septuaginta* is probably the most useful tool which Berthelot had at his disposal in this connection, as it appears to be directly translated from the Arabic of Jabir ibn Hayyan. He deals with this in Chapter [X of Volume I, but it deserves a much fuller treatment. As an example of the superficiality of his work one may mention that, in comparing the list of titles of works of Jabir quoted in the Liber LXX with that given in the *Kitab alFihrist*, he has overlooked the correspondence between the *Intentio Intentionum* of the former with the *Kitab 'Ard al-Irad* of the latter, and that between the *Albicalmon* and the *Kitab Abi Qalamun*, the *Elementum yrci* and the *Kitab Ustuqus al-'Uss al-Awwal*, the *Chapitre des luts* and the *Kitab al-Tin*, and others. [26]

We have seen therefore:

1. That Berthelot had no idea of the vast extent of Arabic chemical literature;
2. That he used the bibliographical material only superficially;
3. That even in this superficial examination he was often very inaccurate;
4. That many of his identifications are unsupported by evidence, and that others are certainly incorrect;
5. That he took no pains to check the dates assigned by him to various authors, even ascribing Avicenna, in one place, to the 12th century;
6. That the texts he printed cannot be said to be properly established, since they were made from single MSS., even where other MSS. of the same works existed;
7. That the works of "Crates" and "Al-Habib" appear to have been unknown to most of the chemists of Islam;
8. That the works of Jabir chosen are not representative;
9. That the absence of appropriate pagination in the texts and translation

renders reference very difficult;

10. That the annotations are few and chiefly concerned with one point only, namely, the relation between Greek and Arabic alchemy;
11. That the use of medieval Latin works to explain Arabic ones is very limited in its application, unless a previous knowledge of the latter has been obtained; and
12. That the most important Latin work employed by Berthelot has received insufficient treatment.

The general impression conveyed by a study of Volumes I and III of *La Chimie au Moyen Age* is, indeed, that of a confused mass of undigested material, rendered still more confused by careless scholarship. It is not surprising, therefore, that the conclusions at which Berthelot arrived are frequently misleading and very often quite inaccurate, while many others require considerable modification. It is to an examination of these conclusions that we must now turn.

Berthelot conclusions on Arabic chemistry

Since Berthelot arrived at conclusions of the widest extent as to the nature of chemistry in Islam, one cannot hope here to deal with the whole matter fully, or even, indeed, with more than a fraction of it. To examine it fully would be to write a complete history of Muhammadan chemistry, for Berthelot has something to say about the earliest period and the latest, in spite of the fact that he did not know what was going on in the meanwhile. I propose, therefore, to state shortly some of the principal points which Berthelot believed himself to have made, and to examine these briefly in order to arrive at some estimate of their worth. This is all the more necessary since historians of chemistry have, up to quite recently, accepted Berthelot's work as authoritative. [27]

> "Les Arabes, en effet, n'ont pas connu les Grees directement, mais par l'intermédiaire des Syriens, qui avaient les premiers traduit les philosophes et les savants grees dans une langue orientale." (Vol. I, p. iv.)

Comment upon this conclusion may be confined to the remark that it is an over-statement of the case, and that, as Steimschneider has abundantly shown, numerous books were directly translated from the Greek into Arabic. One may also refer to the well-authenticated tradition that Khalid ibn Yazid had many

Greek alchemical treatises translated into his mother tongue. Whilst Berthelot has conclusively shown that much alchemy passed to Islam from the Greek via Syriac, he has under-rated the Persian contributions, which were, perhaps, as important as those of the Greeks themselves. Additional light on this subject is being provided by the masterly researches of Prof. Ruska.

> “L’ensemble des ouyrages arabes que nous allons publier, joints aux traités syriaques contenus dans un autre volume, présente un grand intérét pour l’histoire de la science, attendu qu il fournit une connaissance solide de la veritable alchimie arabe, ignorée jusqu’a ce jour.” (Vol. III, p. 25.)

This passage requires the most careful examination, for it makes two definite claims, namely (a) that Berthelot’s work was the first in the field, and (b) that it furnishes a sound knowledge of the real alchemy of the “Arabs”, or rather Arabic writing authors. The first of these two is merely a question of priority and of no particular importance, but it is necessary to point out that Prof. Wiedemann had been working at the subject for several years before Berthelot, and had published some of his researches, which appear to have been unknown to, or neglected by, the latter. Kopp also, although handicapped like Berthelot himself by lack of knowledge of Arabic, had investigated Muhammadan chemistry as far as possible in the circumstances, and had consulted Orientalists on several particular points. Kopp’s work is still of the greatest value, and is characterized by its accuracy. Thus, while Berthelot was certainly the first to publish texts of Arabic chemical books, the work of the two men just mentioned should not be forgotten, especially as in many respects it reaches a much higher level of scholarship than does *La Chimie au Moyen Age*.

The second claim (b), however, is really the crucial question of the whole discussion: In the present articles much evidence has been adduced to enable us to arrive at a considered judgment on the matter, and the inadequacy of Berthelot’s work has, I hope, been made clear. Nevertheless, in order to, place the matter beyond doubt it may be advisable to consider more closely the proportion which exists between the fraction of the material used by Berthelot and the total field.

The period during which chemistry flourished in Islam covers some seven hundred years, from the time of Khalid ibn Yazid (seventh century) to that of Aidamir al-Jildaki (fourteenth century). The chief centers of study were Iraq and Spain, and in that order. Jabir ibn Hayyan (eighth century) was undoubtedly the most accomplished chemist of the early period, and about 80 of his works are extant, whole or in part. The largest and most important is the *Kitab al-Khawass*, or Book of Properties, preserved in two MSS. in the British Museum. It will be obvious that a great deal of work will have to be done before a just estimate of Jabir’s chemical knowledge can be obtained, and it will not be denied that Berthelot certainly was not in a position to make such an estimate. Several of his conclusions on this particular subject have already been proved incorrect, notably his statement that Jabir does not mention the sulphur mercury theory of metals, nor admit “arsenic” as a third constituent of metals.

As far as our information goes, Jabir’s death cannot be placed later than the reign of Al-Ma’mun (813-833 A.D.), so that it is apparent that Berthelot has entirely neglected a period of no less than five hundred years, except for the short articles he has given upon Bubacar (Rhazes) and Avicenna, based on Latin MSS. and therefore not authoritative. His claim that his researches “furnish a sound knowledge of Arabie alchemy” is therefore absurd; even if he had modified it by adding the words

> “as far as it affected European alchemy,”

he would still have been claiming far too much, for the works of Al-Razi and Ibn Sina exercised a great influence upon the future development of the science. Moreover, since it was chiefly in the tenth and twelfth centuries in Muslim Spain that the transmission to Europe flourished, it is undeniable that a study of this period of Islamic chemistry is absolutely essential; and this Berthelot wholly neglected. The important “Letters” of the “Brethren of Purity” (tenth century A.D.), which contain a large section dealing with chemistry, and which were one of the chief sources of chemical knowledge in Moorish Spain, are not even mentioned, in spite of the fact that their plain and straightforward style and notable freedom from mysticism bear the clearest witness to the fact that it was in Islam that chemistry first became a true science. The numerous works of Aidamir al-Jildaki (died about 1360 4.D.), which form a sort of encyclopedia of chemistry and give one a more or less accurate picture of six hundred years of the rise and progress of the science in Islam, together with much biographical information and innumerable lengthy quotations, seem to have been quite unknown to Berthelot. AlJildaki had a better knowledge of the Muhammadan chemists than anyone else had possessed, and he frequently gives long extracts from books which have now disappeared; he is in fact an indispensable source for the study of “l’alchimie arabe.” Fortunately, MSS. of his works are plentiful and copies may be found in all the great European libraries.

As a last source unused by Berthelot may be mentioned the large number of books on minerals and precious and semi-precious stones, which provide material of importance to both the chemist and the mineralogist. Further elaboration of this point seems unnecessary, but one may perhaps remark that, to look at the matter from a numerical standpoint, Berthelot employed less than 4 per cent. of the available material, dealt with only three important chemists (viz., Jabir, Al-Razi and Ibn Sina) out of, at least, two or three dozen who require study, and passed over in silence nearly half a millennium,

It is fitting that these articles, which have contained much criticism of Berthelot's work, should also draw attention to those features which are praiseworthy, and one may readily acknowledge that such features are many. Berthelot's courage in attacking a problem of so great a difficulty was amazing, and that he achieved some measure of success is not denied, even by those who have most strongly felt his deficiencies. After all, it must be remembered that the historical researches were only the product of the leisure of an extremely busy man, and as such they compel our admiration. It is a sufficient testimonial to the worth of the researches on Arabic chemistry, that every one who has worked at the subject since they were published has used them, and perhaps occasionally abused them, but has never been able to neglect them. I feel personally that their chief value lies in the stimulus they give, for no one can read them without realizing that the history of the progress of chemistry in Islam is probably the most important question for the modern historian of science.

The proof of the debt which Islam owed to the Greeks, the elucidation of the great help rendered in this connection by the Syrian translators, the publication of the *Liber LXX* and the nine works of Jabir ibn Hayyan, the translation of the passage from the *Fihrist*, the attention drawn to the important book of " Bubacar " for all these valuable contributions to knowledge Berthelot deserves our warmest thanks. The magnitude of his services was great and should not be belittled on insignificant grounds; yet I think they were greatest not in accomplishment, but in indicating what was to be accomplished. "*Ce n'est que le premier pas qui coite*," and this was taken for us by Berthelot.

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1. Z.D.M.G., 58, 299 (1904).↩
2. Op. cit., pp. 647-659.↩
3. Camb. Univ. Press, 1921, p.3.↩
4. Private communication to the author.↩

5. La Chimie au Moyen Age, iii, 33.↩
6. Op. cit., pp. 32, 33 (“Estagés”).↩
7. Op. cit., p.6.↩
8. Italics mine.E.J.H.↩
9. Op. cit. p. 648. “Dieser grosse Mann besass eben auch grosse Schwachen und zu ihnen zahlte vor allem eine ibermiissige Eitelkeit; sein Leitmotiv auf allen Gebieten, die er bearbeitete, war daher der Satz, den der einstige Schuler im zweiten Teile des Faust mit den Worten ausspricht:”Die Welt, sie war nicht, eh’ ich sie erschuf."↩
10. Needless to say, the necessity of a critical study of the internal evidence, etc., is not by any means precluded.↩
11. Chim. au M. Age, iii. 6.pg 962↩
12. Ibid., p.15.↩
13. 18 Proc. Roy. Soc. Medicine, October, 1923.↩
14. La Chimie au Moyen Age, II, 28.↩
15. Ibid., p.35.↩
16. Ibid., p.4.↩
17. Loc. cit.↩
18. Loc. cit.↩
19. Loc. cit.↩
20. Loc. cit.↩
21. Op. cit. p.2.↩
22. Op. cit. p.3.↩

23. Op. cit. p.5.↩

24. Op. cit., I,301.↩

25. It is improbable that Avicenna knew of Vergil.↩

26. I have not seen Berthelot’s more recent edition of the Liber LXX, in *Archeologie*, 1906.↩

27. Even de Lacy O’Leary has implicitly relied upon him in his Arabic Thought and Its Place in History (1922, p. 120). It is, however, to be noted that Prof. Lynn Thorndike (History of Magic and Experimental Science, 1923, II, 217), whilst accusing Lippmann of belittling Berthelot “on petty pretexts,” himself says “Berthelot is a poor guide in such matters (alchemical MSS. of the Middle Ages) since his pretentious volumes are based on the study of a comparatively small number of MSS. at Paris.”↩